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(54) Planar antenna

(57) An antenna for transmitting and receiving a radio frequency signal comprises a planar radiator (801, 901), a ground plane substantially parallel to the radiator, and a feed point (402, 602, 1106). Further it comprises a separate connector part (404, 604, 1105) for forming an electrical connection between the radiator and the feed point, and means (408, 1101, 1201, 1202) for the mechanical support of the edges of the planar radiator.

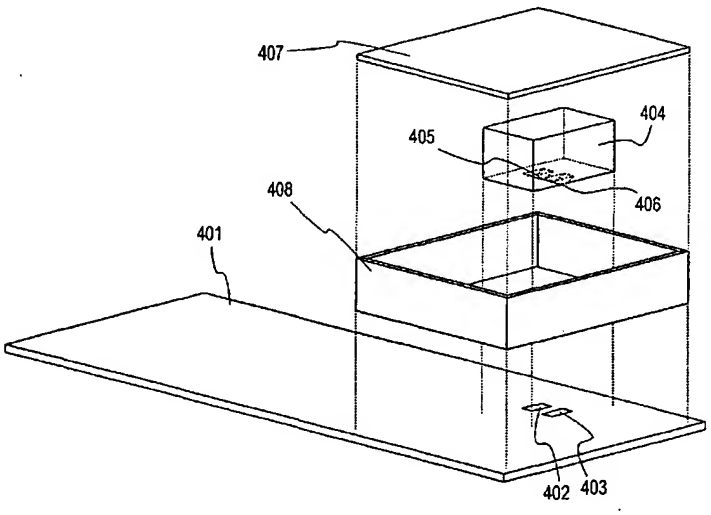

Fig. 4

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Description

[0001] The invention relates generally to antenna structures of radio devices. Particularly the invention relates to a structure of a so called PIFA (Planar Inverted F-Antenna) which is mechanically robust and advantageous regarding the manufacturing techniques.

[0002] Figure 1, shows a known basic model 100 of a PIFA, which has an electrically conducting planar radiator 101, an electrically conducting ground plane 102 in parallel to the radiator, and a grounding contact 103 connecting these two and being substantially perpendicular to the radiator and the ground plane. Further the structure compnses a feed electrode 104, which is also substantially perpedicular to the radiator and the ground plane and which can be connected to the antenna port (not shown in the figure) of a radio device. In the structure according to figure 1 the radiator 101, the grounding contact 103 and the feed electrode 104 are most commonly made from a thin metal plate by cutting a suitable rectangular pattern provided with two projections and by bending the projections at right angles. The ground plane 102 can be a metallized area on the surface of a certain printed circuit board, whereby the grounding contact 103 and the feed electrode are easily connected to bores in the printed circuit board. Generally the dimensioning of the components of the antenna 100 and particularly the size of the radiator 101 and its distance from the ground plane 102 have an effect on the electrical characteristics of the antenna 100.

[0003] A disadvantage of the antenna structure shown in figure 1 is its poor mechanical stability. Different structural alternatives have been presented in order to solve this problem. The patent application EP-484 454 presents a PIFA structure according to the figure 2, where a radiator 201, a ground plane 202 and a grounding contact 203 connecting them are formed on the surfaces of a dielectric body 204. The antenna is fed through a coupling member 205, which does not touch the radiator 201. Between the coupling member 205 and the radiator 201 there is an electromagnetic coupling, and the coupling member extends over the edge of the body 204 to a point, which can be connected to the antenna port of a radio device. The structure is mechanically robust, but the dielectric body component makes it rather heavy. Further, the dielectric body reduces the impedance bandwidth of the antenna and impairs the radiation efficiency compared to an air insulated PIFA.

[0004] The patent publication US-5 510 802 treats a surface mounted PIFA 300 according to figure 3, which comprises a dielectric body 301 and a planar radiator 302 connected to the body. The structure can be dimensioned either so that the radiator 302 will be located very close to the surface of the dielectric body 301, or so that an air gap is left between the components. The coupling from the radiator 301 to the ground potential and the coupling to the radio device's antenna port are effected via the bent projections at the edges of the radiator 301. The structure has the same problems regarding weight, impedance bandwidth and radiation efficiency as the structure shown in figure 2. Further, regarding the manufacturing techniques it is problematic to accurately dimension a radiator bent of a plate and to connect it accurately at a correct distance from the dielectric body.

[0005] The object of the invention is to present an antenna structure which has a simple structure, which is easy to dimension and which has preferred operational characteristics. An object of the invention is also that the antenna structure according to the invention can be easily applied in mobile phones and other small-sized radio devices.

[0006] The objects of the invention are attained with a PIFA structure comprising a support frame for supporting the edge of the radiator and a connector part for arranging the connections of the radiator.

[0007] The antenna according to the invention comprises a planar radiator, a ground plane substantially parallel to the radiator, and a feed point. It is characterised in that it comprises a separate connector part in order to form electrical connection between the radiator and the feed point, and means for the mechanical support of the edges of the planar radiator.

[0008] The antenna according to the invention is intended to be mounted on a printed circuit board, because a printed circuit board is a basic structure in almost all modern small-sized radio devices. The antenna is connected to this so called proper printed circuit board through a separate connector part. The connector part is a body made of a dielectric material having conductor means at least for the antenna feed, and preferably also for the grounding. The radiator is formed on a second printed circuit board which is placed at a distance from the proper printed circuit board corresponding to the height of the connector part. The printed circuit board of the radiator is preferably a so called low-loss printed circuit board, which is commonly used in radio technique so that the high frequency signals would not be absorbed in the material of the printed circuit board. In order to support the edge of the radiator the structure according to the invention comprises a support frame, with which the edge of the printed circuit board containing the radiator is supported either against the proper printed circuit board or against any other mechanical body structure of the radio device.

[0009] The connector part can be soldered to the proper printed circuit board and to the radiator's printed circuit board, or it can be connected to one of them with the aid of connector springs, which form a contact to corresponding connecting spots when the connector part is pressed in its place. In the PIFA according to the invention air forms the dielectric between the radiator and the ground plane, due to which the impedance bandwidth is relatively wide and the radiation efficiency is better than in solutions utilising solid dielectric insulation material. It is easy to dimension the antenna and make the impedance matching by changing the dimensions of

the connector part and the mutual locations of the grounding points as well as the width of the ground contact. A radiator made on the printed circuit board is easy to dimension very accurately, also in large scale series production. Thanks to the support frame the antenna will very well withstand mechanical stress, and the distance between the radiator and the ground plane will not change easily.

[0010] The invention is described in more detail below with reference to preferred embodiments presented as examples and to the enclosed figures, in which

Figure 1 shows a prior art PIFA,

Figure 2 shows another prior art PIFA,

Figure 3 shows a third prior art PIFA,

Figure 4 shows a preferred embodiment of the invention,

Figures 5a and 5b show a detail of the structure shown in figure 4,

Figure 6 shows a preferred embodiment of the invention,

Figures 7a and 7b show a detail of the structure shown in figure 6,

Figures 8 and 9 show some radiators,

Figure 10 shows an antenna printed circuit board,

Figure 11 shows an alternative to realise the invention, and

Figure 12 shows an alternative to support the antenna according to the invention.

[0011] Above reference was made to the figures 1 to 3 in connection with the description of prior art, so that in the following, in the description of the invention and its preferred embodiments, reference is made mainly to the figures 4 to 12. The same reference numerals are used for corresponding parts in the figures.

[0012] Figure 4 is an exploded view showing a preferred embodiment of the invention applied in a mobile phone. For the sake of clarity the figure shows only those components which are of importance regarding the invention, and the perspective views do not show the metallizations on the component surfaces, with the exception of certain connection spots. The direction terms used in the description, such as top surface and bottom surface, refer only to the figure 4, and they do not limit the application nor the manufacturing of the invention to be carried out in any particular position. On the top surface of the printed circuit board 401 there are two metallized connection spots 402 and 403, of which the connection spot 402 is connected to the antenna port (not shown in the figure) of the radio device, and the connection spot 403 is connected to the ground potential. The connector part 404 is pressed against the printed circuit board 401 at the position of the connection spots 402 and 403, whereby the connector part in this embodiment of the invention is a dielectric body in the form of a substantially rectangular prism. Connector springs 405 and 406 are located on its bottom surface so that when the connector part 404 is pressed against the printed circuit board 401 the connector spring 406 touches the connector spot 402 and the connector spring 405 touches the connector spot 403. The antenna printed circuit board 407 is placed over the connector part 404, whereby the pattern formed by a metallization on the bottom surface of this printed circuit board acts as the radiator in the antenna structure according to figure 4.

[0013] Further figure 4 shows a support frame 408 which is a rectangular encircling box-like component made of a relatively thin dielectric material and having sides with lengths corresponding to the lengths of the antenna printed circuit board 407 sides. In the embodiment presented in figure 4 the support frame 408 is fixed at its bottom edge to the mobile phone's printed circuit board 401 and at its top edge to the antenna printed circuit board 407. For instance glue or any other fastening method known per se by a person skilled in the art can be used for the fastening. That area of the surface of the mobile phone's printed circuit board 401 left inside the support frame 408 comprises a ground plane (not shown in the figure), which is a metallized area covering the surface of the printed circuit board, except such narrow zones which are required in order to isolate the connecting spot 402 acting as the antenna feed point and any other such components which shall not be grounded from the ground potential.

[0014] However, the invention is no limited to the use of the printed circuit board as the ground plane of the antenna. Advantageously a separate metal plate or a metallized dielectric plate can also be used as the ground plane. The frame of the device, such as the frame of a mobile phone, or a metallized part of the frame made of a dielectric material, can also be used as the ground plane. If the device has a solid metal frame, then the frame can be used as the ground plane by fixing the antenna outside the frame. An embodiment utilising the frame as the grounding plane can be realised for instance in the manner according to the figure 4 by replacing the printed circuit board 401 with the device's frame and by arranging the feeding of the non-grounded feed points of the antenna through the frame (not shown in the figure). If the frame is made of a conducting material the non-grounded feeding points, i.e. the connecting spots 402 must of course be isolated from the frame in any manner known by a person skilled in the art.

[0015] Figure 5a shows the connector part 404 of the

antenna structure of figure 4 and the antenna printed circuit board 407, as seen from the direction A presented in figure 4; the figure 5b shows the same parts, as seen from the direction B. In order to arrange the antenna feed and the grounding there are conductors arranged on the surfaces of the connector part 404, of which the conductor 501 extends from the connector spring 405, as seen in the figure, along the left side surface of the connector part all the way to its top edge, and the conductor 502 extends in a mirror fashion from the connector spring 406 along the right side surface of the connector, all the way to its top edge. The soldering 503 connects the top end of the conductor 501 to a certain first location of the metallization 505 on the antenna printed circuit board, and the soldering 504 connects the conductor 502 to a second location of the metallization 505 on the antenna printed circuit board.

[0016] The figures 6, 7a and 7b present another embodiment according to the invention, where connector springs 605 and 606 are located on the top surface of the connector part 604. The connector part 604 is soldered to the connection spots 602 and 603 on the mobile phone's printed circuit board 601, and the connector springs 605 and 606 form a contact from the connector part 604 to two points of the metallization 505 on the antenna printed circuit board 407, due to which the form of the conductors 701 and 702 is slightly different than the form of the conductors 501 and 502 presented above. In other respects this embodiment is similar to that of the figures 4, 5a and 5b.

[0017] The invention does not impose any restrictions on the form of the radiator used in an antenna according to the invention, i.e. on the form of the pattern formed by the metallization on the antenna printed circuit board. The figures 8 and 9 show two possibilities for making the radiator. The radiator is marked by hatching. In figure 8 the radiator 801 is a uniform conducting rectangle, which covers the whole bottom surface of the antenna printed circuit board 802, except its very edges. When the edges are left uncoverd the radiator will not touch the support frame, and no energy is absorbed in the material of the support frame. The locations 803 and 804 are those where a contact is formed between the radiator and the soldering spots or connector springs on the connector part (not shown in the figure). In figure 9 the radiator 901 has a more complicated form, because the antenna printed circuit board 902 has two non-conducting areas 905 and 906. The purpose of the first non-conducting area is to increase the electrical distance between the contact spots 903 and 904, where the contact is made between the radiator and the soldering spots or contact springs on the connector part (not shown in the figure). The electrical distance between the contact spots 903 and 904 has an impact on the antenna feed impedance. The second non-conducting area 906 increases the electrical length of the radiator 901, which has an impact on the resonance frequency of the antenna: the longer the electrical length of the antenna the lower is the resonance frequency. The best suited size and form of the non-conducting areas in each application can be determined experimentally. By experiments it is also possible to find other preferred radiator forms. Both embodiments shown in the figures 8 and 9 can be used in an antenna based on the principle of either figure 4 or figure 6.

[0018] Figure 10 shows in section an antenna printed circuit board 1001, which can be used instead of the above presented antenna printed circuit boards. In contrast to the presentation above the antenna printed circuit board 1001 has a metallization 1002 acting as the radiator on the top, and not on the lower side. In order to have a certain first point of the radiator in contact with the antenna feed poin the antenna printed circuit board 1001 has a through metallized bore 1003, which connects a certain point of the radiator with the connection spot 1004 on the lower surface of the antenna printed circuit board. For the grounding the edge metallization 1005 extends around an edge of the antenna printed circuit board and connects a certain second point of the radiator with a second connection spot 1006. The invention does not impose any limitations on how the through metallized bores and the edge metallizations are used to feed and to ground the radiator: both can be through metallized bores, both can be edge metallizations, or one can be a through metallized bore and the other can be an edge metallization. All these embodiments can be used in an antenna according to the principle shown in either figure 4 or in figure 6.

[0019] Figure 11 shows an alternative method for supporting the edge of the antenna printed circuit board of a PIFA according to the invention. In this case the support frame 1101 is not fastened to the mobile phone's printed circuit board 1102, but the support frame is a part of the mobile phone's cover 1103. The antenna printed circuit board 1104 is fastened to the support frame 1101 by gluing, by a mechanical locking, or in any other manner known per se to a person skilled in the art. The connector part 1105 can be fastened to the antenna printed circuit board 1104 as in the figures 4 and 11, whereby it has connector springs (not shown in the figure) in order to form contacts with the connector spots 1106 and 1107 on the printed circuit board of the mobile phone, or it can be a connector part according to figure 6 fastened to the mobile phone's printed circuit board.

[0020] It is not necessary that the support frame supporting the edge of the antenna printed circuit board is a continuous one as that presented above, but it can be formed of two or more sections 1201 and 1202, for instance according to figure 12. This is the case both for the mobile phone's printed circuit board and the support frame fastened to the cover of the mobile phone. However, a uniform support frame provides the best mechanical support.

[0021] The invention does not impose any high requirements on the materials used in the structure according to the invention. The printed circuit board of the

mobile phone can be made of any common and generaly used printed circuit board material. The support frame can be for instance extruded or moulded plastics. The connector part can be of a plastic or a ceramic material, which is similar to that which is used in dielectric filters. The metallizations on the surface of the connector part can be made by a method similar to that with which metallizations are made on the surfaces of dielectric filters. The antenna printed circuit board is most advantageously a so called low-loss material used for instance in micro-strip circuits inteded for high frequencies. It is advantageous to manufacture the radiator as a metallization on the surface of a low-loss printed circuit board (in the same way as known micro-strips are manufactured), because the manufacturing process can be well controlled, and it is easy to obtain an exact design and dimensioning of the radiator.

[0022] The dimensioning of the radiator and of the number and form of any used non-conducting areas on the antenna printed circuit board are determined by the resonance frequency and impedance bandwidth required of the antenna. Preferably the connector part is in the lateral direction as narrow as possible; in the above presented figures the connector part is shown exaggerately large for the sake of clarity. The maximum width of the connector part is determined by the required minimum distance between those points where the connector part forms the electrical contact with the metallization of the antenna printed circuit board.

[0023] A PIFA according to the invention is particularly well suited for mobile phones where it is totally located within the cover of the mobile phone. The proportion of the total radiation which is absorbed in the user's hand is the lower the farther away the antenna radiator is located from the user's hand in the normal operating position. In this respect it is more advantageous to locate the radiator on the bottom surface than on the top surface of the antenna's printed circuit board, because the distance between a radiator located on the bottom surface and the user's hand touching the mobile phone's outer cover is extended by the thickness of the antenna's printed circuit board. Disregarding the location of the radiator the antenna is totally located within the mobile phone, due to which the antenna does not limit the design of the appearance of the mobile phone. Further the antenna is not as vulnerable to blows and will not get as easily entangled as a prior art projecting antenna of a mobile phone. Further the grounding plane substantially prevents the antenna according to the invention to radiate in that direction, which seen from the radiator is towards the grounding plane. This can be utilised by locating the radiator and the grounding plane within the mobile phone so that in the normal operating position the grounding plane is between the radiator and the head of the user. When no radiation is absorbed in the user's head a larger part of the radiation is obtained for useful operation, which reduces the waste of electric energy in the mobile phone and increases the life of the battery between recharging.

[0024] The above presented invention is not limited to the presented exemplary embodiments nor to any particular application, but it can be used in antennas in different applications and on different frequencies, advantageously on radio frequencies, such as UHF and VHF. The structure can be advantageously used in mobile phone structures. The structure can be modified without leaving the scope defined by the claims presented below. As an exemplary modification can be mentioned the forming of different matching circuits on the side surfaces of the connector part by using strip lines or discrete components, which are fastened to the connection spots formed on the surface of the connector part. Another modification is to arrange the radiator grounding on the surface of the support frame and not on the surface of the connector frame, whereby only the antenna feed is supplied via the connector part.

Claims

1. An antenna for transmitting and receiving a radio frequency signal, whereby the antenna comprises a planar radiator (801, 901), a ground plane substantially parallel to the radiator, and a feed point (402, 602, 1106), **characterised** in that it compnses a separate connector part (404, 604, 1105) for forming an electrical connection between the radiator and the feed point, and means (408, 1101, 1201, 1202) for the mechanical support of the edges of the planar radiator.

2. An antenna according to claim 1, **characterised** in that the connector part further comprises means (406, 502, 606, 702) for forming a grounding connection between the radiator and the ground plane.

3. An antenna according to claim 1, **characterised** in that the connector part (604) comprises at least one connector spring (605, 606) in order to form a detachable contact between the connector part and the radiator.

4. An antenna according to claim 1, **characterised** in that the connector part (404) comprises at least one connector spring (405, 406) for forming a detachable contact between the connector part and a separate printed circuit board.

5. An antenna according to claim 1, **characterised** in that it comprises a low-loss printed circuit board (407, 802, 902, 1104), and that said radiator is a metallic pattern (801, 901) on the surface of the low-loss printed circuit board.

6. An antenna according to claim 5, **characterised** in that in order to mechanically support the edges of

the planar radiator it comprises a uniform support frame (408, 1101), which is substantially of the same size as the outer edge of the low-loss printed circuit board.

7. An antenna according to claim 6, **characterised** in that the ground plane is on the surface of a certain printed circuit board (401, 601, 1102) and that the support frame (408) is arranged to be fastened between the printed circuit board and the low-loss printed circuit board.

8. An antenna according to claim 6, **characterised** in that the support frame (1101) is arranged to fix the edges of the low-loss printed circuit board to the outer cover (1103) of that radio device, in connection with which the antenna is used.

9. An antenna according to claim 5, **characterised** in that in order to mechanically support the edges of the planar radiator it comprises at least two separate support frame sections (1201, 1202) in order to fix two different points of the outer edge of the low-loss printed circuit board to a certain other part of that radio device, in connection with which the antenna is used.

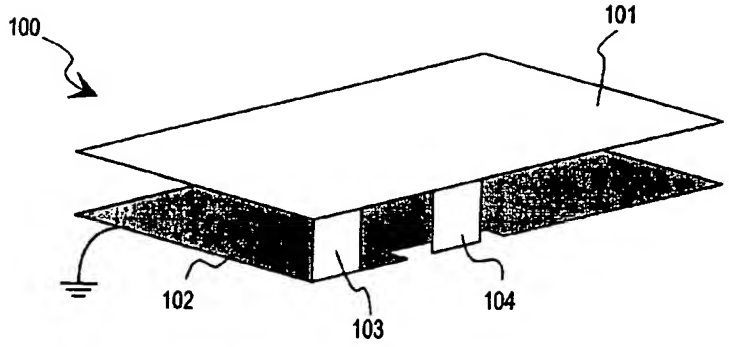

Fig. 1
PRIOR ART

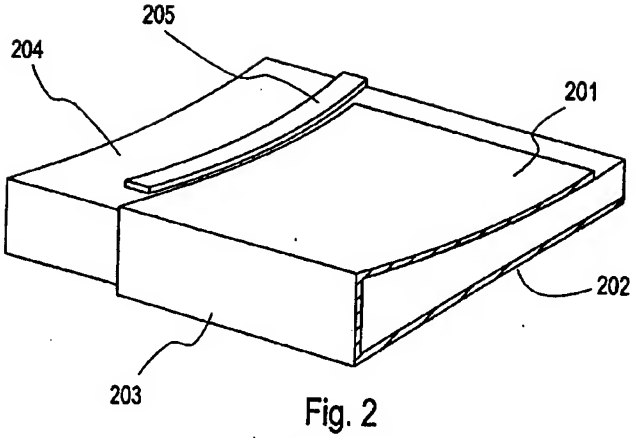

Fig. 2
PRIOR ART

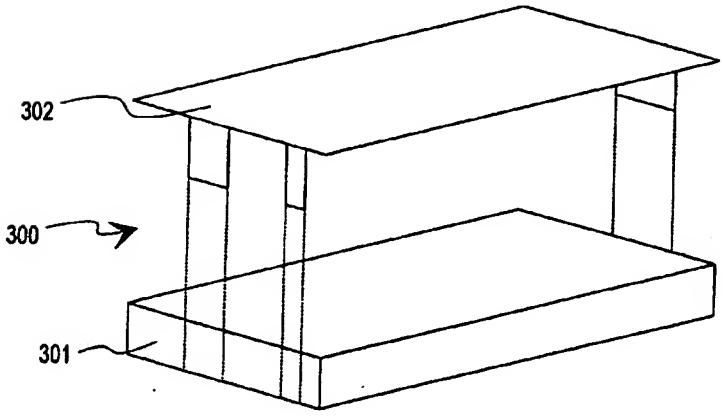

Fig. 3
PRIOR ART

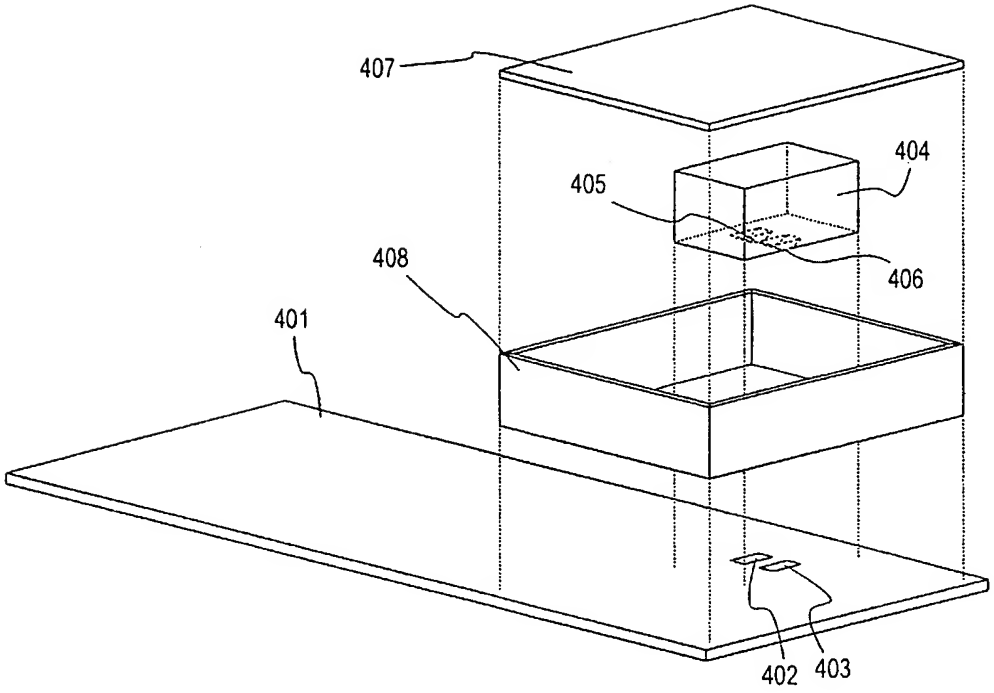

Fig. 4

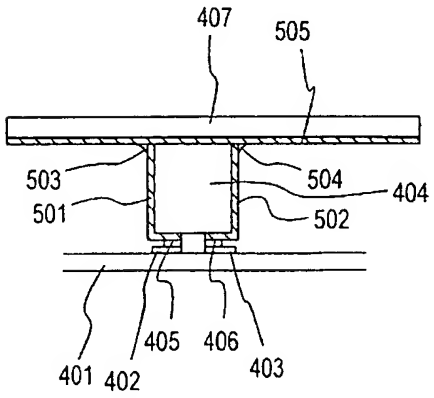

Fig. 5a

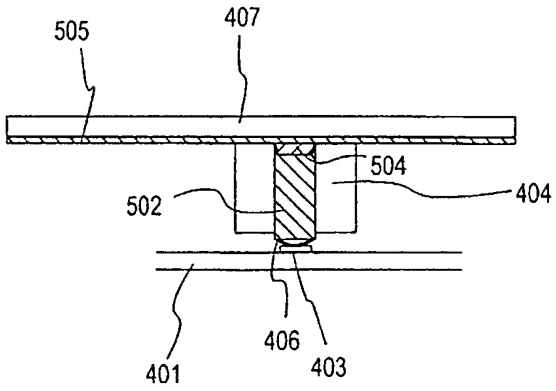

Fig. 5b

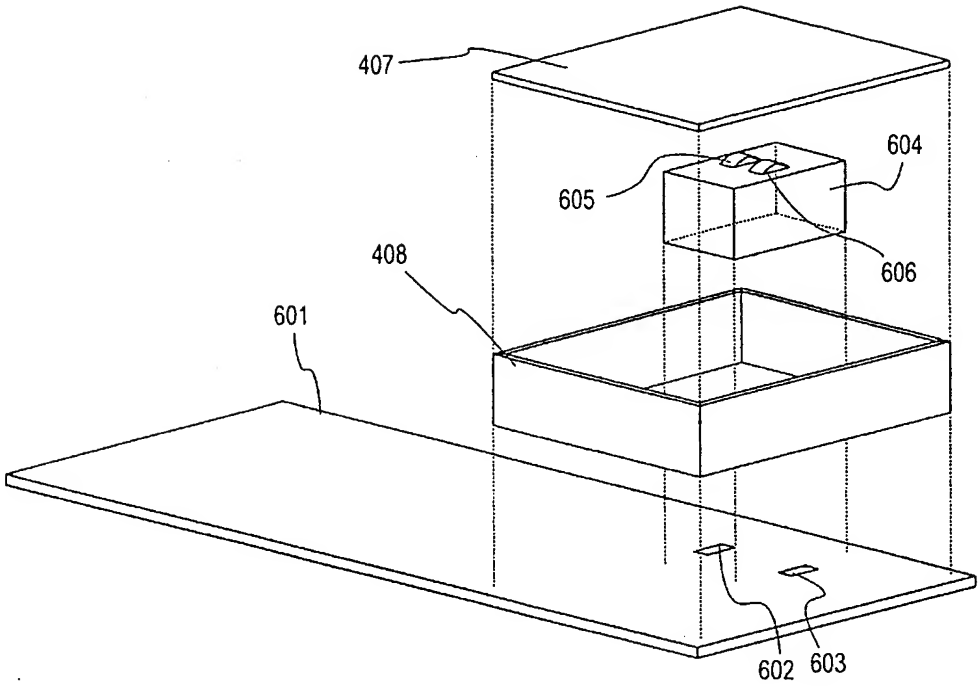

Fig. 6

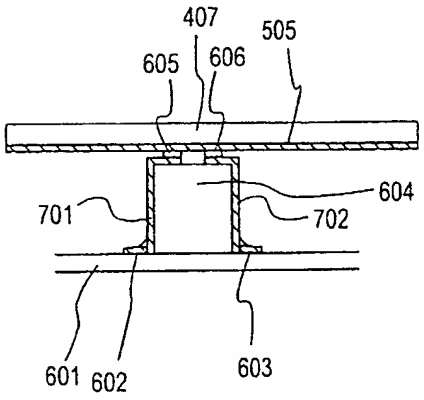

Fig. 7a

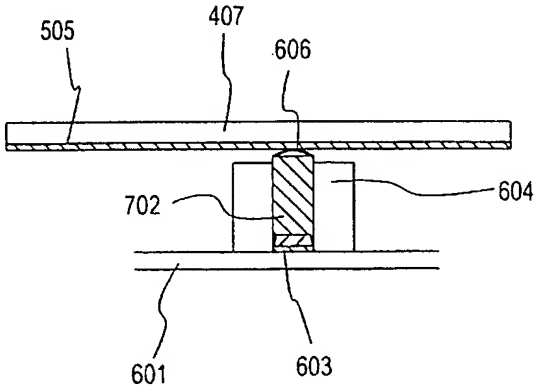

Fig. 7b

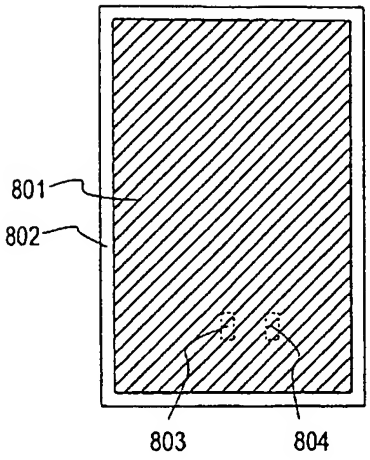

Fig. 8

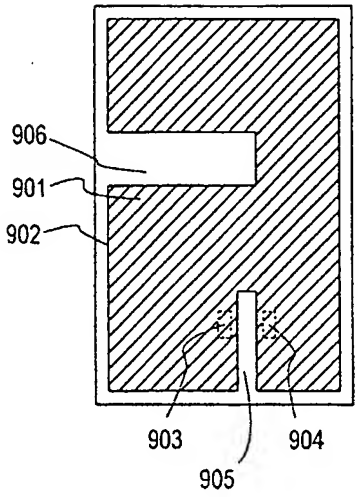

Fig. 9

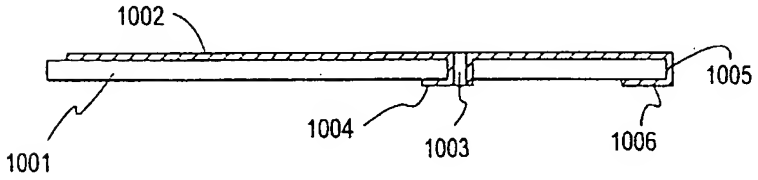

Fig. 10

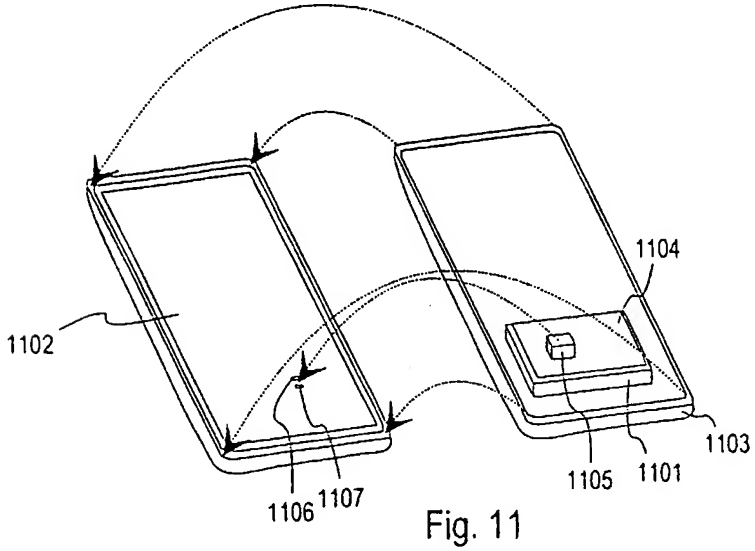

Fig. 11

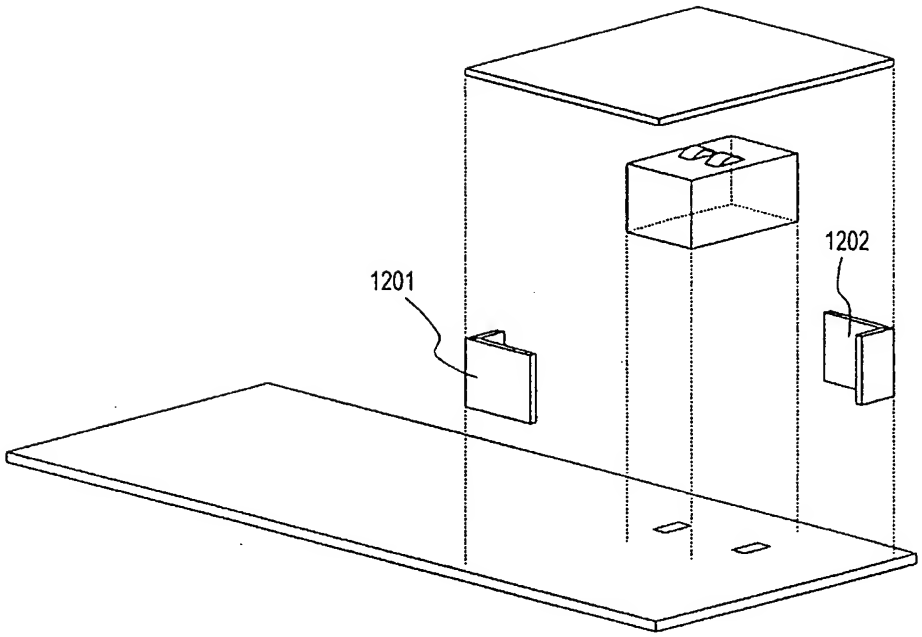

Fig. 12